On Certain Principles and Methods in the Surgical Treatment of the Paralysis of Children

Being an Address delivered before the Huddersfield Medical Society

BY

ROBERT JONES

Surgeon Royal Southern Hospital, Liverpool, and to the Liverpool Country Hospital for the Chronic Diseases of Children

London

JOHN BALE, SONS & DANIELSSON, Ltd.

OXFORD HOUSE

83-89, GREAT TITCHFIELD STREET, OXFORD STREET, W.

1902

On Certain Principles and Methods in the Surgical Treatment of the Paralysis of Children.

Mr. President and Gentlemen,—I offer you my sincere thanks for the honour you have conferred on me by inviting me to address your Medical Society. The subject upon which I venture to speak is one which has interested me for many years, and is well worthy of careful study. In these days, strange to say, when so much is written on every branch of medicine, the surgery of the paralysis of children has earned but scant attention, and that only in odd places and at odd times. There are many reasons suggestive of the explanation. To the general surgeon the subject presents many difficulties. It abounds in detail and demands a patience that only enthusiasm can supply. Operations, be they performed, only attain their purpose when followed by prolonged, intelligent, and carefully thought out after-treatment, and this involves not only a practical knowledge of the sequence of events, but a very real faith in certain fundamental principles. Short of this faith, the surgeon is half-hearted in his measures, and the patient and friends lose that confidence which inspires hope. The surgeon,

therefore, should know the theory of his subject, and be able definitely to direct practically the mechanical details which are the accompaniment of all operative aid. What would we think of a physician who, having made a diagnosis, leaves his unfortunate patient in the hands of a chemist, who is asked to administer what he thinks to be an appropriate drug? And yet this is not a travesty, but the grim experience of hundreds of paralytic cripples in this country. They pay their consultation fees, and are then despatched to the instrument maker who is merely desired in the most general terms to fit on a "suitable" appliance. Is it any wonder, therefore, that quackery abounds, and that the unfortunate patient is, so long as money lasts, relegated to suits of armour bristling with screws and ratchets? The treatment of paralytic deformities is both mechanical and operative. The one is inseparable from the other, and the surgeon who is not a mechanic is little better than the old orthopædic surgeon who, without any operative education, looked upon a complicated splint as the universal panacea. To the late Mr. H. O. Thomas belongs the credit of having preached the gospel of simplicity as applied to splints. In paralytic affections, his only implement was a tenotome, and yet so skilful was he in mechanical resource that he rarely failed to rectify the most obstinate deformity. From him I learned the value of rest in restoring power to overstrained muscular fibre, and the immense importance of

postural prophylaxis in relation to deformity. Since his death, many important advances have been made on the operative side, but the mechanical principles he enunciated are in advance of much of the teaching of the present day.

Acute Infantile Paralysis.

I will, with your permission, sir, deal first with certain aspects of acute infantile paralysis, viewed chiefly from its clinical side. We all recognise the great importance of this subject, if only from the fact that next to rachitis it is the most prolific source of deformity, a deformity which never disappears spontaneously. Whenever we meet with a paralytic deformity with shortened muscle or diminished joint movement, it can be safely assumed that, either from lack of knowledge or from neglect, a condition has arisen which could quite well have been avoided. Joint malposition due to muscle shortening or contracture arises from insufficiently opposed muscular action, or from faulty posture, due generally to the influence of gravity. Either condition the surgeon's art should easily enable him to prevent. Provided we know in any given case the etiology of its deformity, we must not be content to meet it half way, but should endeavour to prevent it from ever making its appearance. In a completely paralysed arm the deformity to prevent is one of extension of the wrist and elbow, and partial flexion of the fingers. At the ankle it is extension and inversion, or eversion; at the knee, flexion; at the

hip, flexion, often with external rotation. The causation of these deformities has been often discussed, but of one thing we may rest assured, and that is, that the old theory of the action of antagonistic groups is neither the sole cause nor even the most important etiological factor. This is evident when we note that deformities occur when paralysis of all the muscular groups is complete, and furthermore, that when paralysis is incomplete the shortened or contracted muscles are sometimes found to be the paralysed ones. We must indeed look upon several factors as instrumental in the production of paralytic deformities, such as gravity, body weight, the shape of articular facets, and to a lesser degree, unbalanced muscular action. To take an example, if all the muscles governing the foot are paralysed and walking is not attempted, the deformity will be precisely that which any foot assumes when left unconsciously hanging, as in anæsthesia ; that is an equino-varus, the fixation and muscle shortening being quite secondary. If, however, walking has been the habit, we will get an equino valgus or calcaneus in response to superincumbent body weight, applied in the one case to the inner side of the foot, or in the other to the back of the heel. Similarly in the case of the knee. If crutches have been used and the knee has been allowed to swing, flexion is the result, which is the position naturally assumed by a limb whether paralysed or not, left a mere pendant to the pelvis. If, however, the limb be used for walking, other

deformities may occur. Hyperextension or recurvation if the body weight falls on the heel, and genu valgum when body weight is brought to bear upon an everted foot. And so every deformity is produced in a manner which can be easily ascertained when we examine the patient and his habits, and I emphasise the matter because of its prophylactic bearing.

In the limb not completely paralysed, contractions of the more powerful groups of muscles act very harmfully on their opponents, and it is the recognition of this fact which constitutes the keynote to both the mechanical and operative treatment.

In the past we have all been too much governed by the pathology of the affection to do justice to its clinical aspect. Because certain groups of muscles have barely responded to stimuli, and have remained inactive, it is too often assumed that this is due to cell destruction in the motor area. This assumption, if correct, would render useless any effort on the part of surgery. What we have to recollect, however, is that the cell destruction is not so extensive as would appear, and that the affection, so far as the majority of the cells are concerned, is a transient and a recoverable one. We have no time this evening to consider the many interesting points in connection with pathology, more especially its infective origin; but we must not be led astray by any reports made on the cords of children dead months and years after the onset of the affection. At this stage many secondary changes have occurred

and we have yet much to learn concerning the changes and degenerations of cells secondary to muscular desuetude. Careful and extensive investigation of the cords of subjects months and years after the loss of limbs, and similar experiments on growing animals, would throw an interesting side-light upon the cell changes found in polio-myelitis of long standing.

Let me take as an example paralytic drop wrist. This deformity is of slow growth, and untreated never recovers. The principles governing its treatment are so little understood that at the present moment there are thousands with crippled, useless hands, who have received neither hope nor help from whomsoever they have consulted. And yet the majority of such deformities are most amenable to treatment, and do not even require the knowledge which the practice of a speciality involves. Let me for a moment allude to cases in order to add clinical weight to my remarks.

Case 1.—Some fifteen years ago a youth, aged 19, came to me with loss of power in his arm and a typical wrist drop. He gave the history of what he called a "tooth" stroke at the age of 2. He had no power of voluntarily extending his hand, and the wrist could only be extended by the surgeon when he exercised considerable force; as the wrist became extended the fingers flexed. He had but slight movement of the fingers, just enough to enable him to hold a stick while the wrist was acutely flexed. For reasons which I will explain

later, I was able to tell him that even at this period, seventeen years after the onset of the affection, his hand could be made quite useful. In less than two years he was able to flex and extend his wrist, and perform movements of considerable nicety with his fingers.

Case 2.—A young woman, aged 23, the subject of polio-myelitis twenty years previously, presented herself with a contracted hand, which could only be extended by moderate force. When forcible extension was adopted the wrist could only be extended by permitting flexion of the fingers. Advice had been sought from several neurologists, and massage and the battery invariably recommended. For some years all treatment had been discarded, and the only attention paid to the hand by the patient was in endeavouring to keep it out of sight. After carefully examining the muscles, I assured her that treatment would ultimately prove very satisfactory. Again, in less than eighteen months, she was enabled, slowly, but with considerable precision, to flex and extend her wrist, and to move her fingers separately.

It is needless to multiply cases, but to many of us such results would seem incredible until the explanation in all its simplicity were vouchsafed. These two cases had remained untreated because muscles powerless from desuetude were mistaken for muscles paralysed from cell destruction. To begin with, perhaps the whole arm was paralysed; then the strong group of flexors recovered; later

the extensors. The flexors, however, having first got well, overpowered the extensors, and aided by gravity became shortened or contracted while the extensors were stretched out and lengthened. This, then, is the secret of the prolonged disability—a group of muscles placed at mechanical disadvantage had become impotent from desuetude. Well, then, how is the surgeon to know the case where he can assuredly, as I did, give a confident prognosis? The test is simple. He asks the patient to move his fingers in the direction of extension. The patient says he cannot. The surgeon then grasps his wrist and still further forcibly flexes it. The patient is then asked to extend his fingers from their new position. If he succeed ever so little a favourable prognosis may be given. Should he fail, then treatment is of no avail. The treatment is based upon Thomas's theory of muscle shortening, and consists in a recognition of the mechanical principles governing the production of contractures. In the paralytic wrist one group of muscles is lengthened and another is shortened by posture, and treatment must be directed to the reversal of these conditions. In other words, we must slowly stretch and lengthen the flexors and place the extensors in such a position that their structural shortening will ensue. We have no opportunity at present to enter fully into methods, but when I state that the wrist and fingers must be placed in hyperextension for very many months, the principles of treatment will be sufficiently appreciated. The test of

recovery consists in the power of the patient to voluntarily extend his fingers from the splint upon which his hand rests. I have dealt at some length on this aspect of the question, because the principle underlying it has received but scant allegiance, and furthermore because it influences our every effort whatever joint or limb be affected. We must not attempt to treat a weakened set of muscles without first rescuing them from being overstretched, and we must carefully note that we can but restore to action elongated muscles by maintaining them in a slackened posture. There are many analogies in confirmation to which I could draw your attention, but I will confine myself to the consideration of only one or two. We all know that congenital club foot is not a paralytic affection, we are also conscious that apparently, after treatment has resulted in rectification, a so-called recurrence is frequently chronicled. Why should that be? I am quite sure I can give you the explanation. It is due entirely to the fact that the extensor muscles have not sufficiently recovered to resist the action of gravity, in other words, the patient is unable to hold the foot at right angles. A recurrence therefore merely means the formation of a paralytic deformity exactly as it occurs in polio-myelitis, where the extensors of the toe are affected. It can be prevented by keeping the foot over-corrected until the extensor muscles have, as the nautical expression goes, "taken in their slack." When a talipedic foot can be voluntarily raised to above

a right angle a recurrence cannot possibly occur. Here, then, is an admirable confirmation in a non-paralytic case of impotence from desuetude. You will see therefore, that we have clinical data which will enable us to say whether or not a paralytic drop wrist is recoverable, and we know that the severity of the contractions and the duration of the disease do not contra-indicate a favourable prognosis. As an aid to prognosis we may note that the structural shortening of the flexors is a more serious impediment to recovery than the long duration of the disability.

In illustration of the value of preventing a pull upon paralysed muscle, you may be interested in an experiment I made some months ago. A relative, in whom I was much interested, was attacked by paralysis of the facial nerve, probably due to effusion into its sheath. For several weeks only a slight improvement was manifest. I therefore fixed on his face an apparatus so designed as to draw the angle of his mouth on the paralysed side well up towards the ear. In less than a fortnight he had so far recovered as to be able to dispense with it, feeling very grateful for its manifest help. A similar instrument tried upon a second case, when the paralysis had lasted four months with but little abatement, acted almost as a charm, and was worn for a month—only because the patient feared a recurrence from too prematurely discarding it.

An interesting confirmation of this principle occurred in two cases of paralysis of the shoulder

girdle, when all the muscles above those governing the hand were affected. The arm lay helplessly by the side, and even the hand responded but imperfectly to the will. The elbow was flail and quite uncontrolled by any group of muscles. Such an arm is obviously of but little use to a patient, having to be lifted by the opposite arm. It struck me that it would be advisable, if possible, to permanently fix the arm at an angle so calculated that the hand might be brought into contact with the face and neck. Arthrodesis of the elbow I knew to be an unsatisfactory operation, and I decided therefore to make the fixation by means of skin incisions. The arm was first brought to an angle of 45 degrees, and one judged by the relative position of the arm to forearm how large a piece of skin it was necessary to remove. The elbow was next extended, and a diamond-shaped incision mapped out and the skin removed. The upper angle of the wound was next attached to the lower, and the bare surface of the lower triangle laid in juxtaposition to that of the upper triangle. A scar was thus formed sufficiently firm to hold the elbow flexed. In two of seven cases I operated upon, interesting phenomena followed. Paralysis was thought to be complete in the biceps and brachialis anticus, but some months after the arm was flexed flexion power was restored to the elbow. This power was brought about by the postural release from strain cast upon muscles, and still further elucidates the question we are discussing.

I trust, gentlemen, I have been able to impress upon you the importance of not confusing muscles which for years have been useless, with muscles which are positively paralysed. It is this confusion which has hindered both physician and surgeon from accurately gauging, in these cases, the potentialities of recovery. Treatment must be obviously conducted with a view of preventing, or of correcting, structural shortening of muscular groups. This in the hand generally means hyperextension of the wrist, in the elbow flexion, in the knee extension and rectangular fixation of the ankle.

Tendon Transplantation.

Considerable assistance has been afforded paralytic children by the recent introduction of tendon transplantation and the revival of arthrodesis. Tendon grafting consists in attaching a healthy tendon either into a paralysed one or into the periosteum, and so to speak, changing the sphere of its action. It is quite a mystery how an amicable arrangement between mind and muscle is brought about, for a muscle hitherto directed to evert the foot, is now asked to invert it, and by the intervention of some law of adaptation, it obeys. What interesting possibilities in connection with the nervous system, this suggests! Already I have operated upon over fifty cases, and without entering into any details, it may be interesting to chronicle my experiences.

The operation in my hands has been most successful, where one muscle or one group of muscles has been paralysed. This is exemplified in paralysis of the peronei or of the tibiales. In one case reinforcement comes from the extensor proprius pollicis and tendo achillis; in the other from part of the tibialis anticus and the tendo achillis. Transplanting the peroneus longus into the tibialis posticus or the converse, is sometimes disappointing, because of adhesions by the way and the angular cross country tour which the healthy muscle is forced to take. The operation should not be performed with the object of strengthening partially paralysed muscles, or muscles weakened by elongation. In such cases our opportunity comes for testing the value of what I have stated regarding the mechanism of shortened muscles. If any operation be called for, lengthening of the shortened tendons and shortening of the lengthened ones are clearly indicated. Again, in flail-like joints, tendon splicing is of no avail, because superincumbent body weight is too fatal an antagonist. Another most important point is to employ the nearest available tendon, if it be sufficiently strong, rather than one from a distance; and where it is possible, the selection should be made of a reinforcing muscle, the line of which is parallel to the reinforced. Take for instance a talipes calcaneus, where we would by preference rectify it by the aid of the peronei, or in paralytic valgus, where we can with advantage command the services of the extensor proprius

pollicis. In analysing my failures, I ascribe, perhaps, the principal share to a want of success in preventing the reinforcing tendon from taking a tortuous route. Another cause of failure may be avoided if the operator makes a point of completely correcting or, better, even over-correcting a deformity before transplantation is performed. For instance, a girl walks with paralytic valgus and has done so for years. The foot cannot be placed in inversion without the application of great force. If transplantation of a slip of the achilles tendon is to be productive, the foot must first of all be kept inverted by mechanism until all strain on the inner aspect of the foot has been removed. I would further urge that if tendon is to be spliced to tendon, let it be done as near its insertion as practicable, so as to avoid as much as possible a yielding of the paralysed section, which we know is apt to occur. Whenever the tendon can be transplanted into periosteum I am convinced it should be done, care being taken to secure a really firm hold of the tissue. When attached to tendon, a neat splice should be tried, for many failures are due to clumsy bulky excrescences which encourage adhesions and otherwise obstruct the easy gliding of the tendon. Finally, the proximal part of the reinforcing tendon should be fixed into the paralysed tendon so that it be maintained as tense as possible, otherwise we have to face the problem of a slack tendon which cannot do its work.

If these practical points be remembered by

surgeons, and a watchful eye kept upon the first attempts at walking, in order that the body weight be correctly exercised on the tarsus, tendon transplantation cannot fail of a good and lasting reception.

Arthrodesis.

There is another class of cases which has interested me greatly—I allude to those paralytics with joints either hopelessly flail-like or sufficiently so as to demand unceasing mechanical attention. The difficulty and expense connected with the purely mechanical treatment of these cases, extending as it does, over the whole of a lifetime, is an effective barrier to the poor of our cities. The recognition of this fact induced me to urge, at the Bristol Meeting of 1894, a revival and extension of operative procedures which for years had remained in abeyance. I allude to the operation of arthrodesis which aimed at transforming a flail limb into a member as rigid as the splint which it was desired to discard. In a large majority of the so-called paralysis of the lower limb, the psoas and iliacus muscles are unaffected and all mechanical means are therefore based, if to be of real use, upon the integrity of the muscles. The knee and ankle are kept fixed and the psoas muscle is prepared to carry the leg, splint and all. In consequence, these weakly paralytics easily tire of the weight of their supports and therefore lose

the opportunity which presents to strengthen their only pair of muscles of progression.

The operation consists in opening the joint with a sharp gouge, peeling the cartilage off the whole articulation in the case of the ankle, and gouging the bone in the case of the knee, keeping the joint completely at rest for some weeks subsequently, and for a long period fitting the limb with a simple apparatus which will enable the patient to walk without throwing a strain upon the newly-fixed joints. An excision is more than the case requires, and involves a greater sacrifice of tissue than an already shortened limb can spare. To expose the knee I make an incision across the front of the joint, covering fully half its circumference, and curved so as to pass below the lower end of the patella. The flap is turned up, and all the vessels ligatured. I next remove the semilunar cartilages, and with a sharp, short-bladed knife or gouge peel away the cartilages and the underlying layer of bone, so as to leave a raw surface over the whole of their extent. The crucial ligaments I generally leave intact. The structures are then carefully reunited by deep and superficial sutures, no drainage-tube, of course, is employed, and the wound is well covered with sterilised absorbent wadding.

The operation may be carried out in the ankle-joint in one of two ways, according to the circumstances of the case. In old cases, where the foot is deformed and assumes the equino-varus variety,

the astragalus is well to the front. In such, I force the foot into a position of extreme equino-varus, and make an incision in front of the external malleolus, following the line of the ankle-joint, and dividing all structures down to the astragalus, generally only severing the peroneus tertius tendon. The other tendons are held aside, and the articulating surface of the astragalus exposed. With a gouge or knife several grooved portions of the articulating cartilage are removed. If complete bony ankylosis of the ankle be desired, it will be necessary to gouge bone. If a fibrous ankylosis be desired, it will be sufficient to peel off parts of the cartilage. The ankle is kept extended while some pieces of the articulating surfaces of the tibia and fibula are removed. A few vessels are tied, the foot is placed in its normal relation to the leg, and a suture or two close the wound. A pad of wood-wool tissue is applied over all, and this being firmly bandaged, the procedure is complete.

In other cases, the astragalus is more easily approached from behind, and in such the foot is firmly flexed on the leg, and an incision down to the bone is made along the external border of the tendo achillis. The posterior ligament is now freely divided, and the gouging takes place as in the former operation.

No serious mishap has occurred in any of my series of over 100 cases. Every wound but three has healed by first intention ; and contrary to expectation, those cases where trophic changes

were most marked, healed as readily as those whose nutritive conditions were nearer normal.

In talipes calcaneus, where the paralysis is not complete, a deformity often accompanied by pes cavus, and for which Willet's operation of shortening the tendo achillis is performed, I recommend a modified arthrodesis. It gives distinctly satisfactory results. Willet's operation is rarely successful, for the moment we try to pit a weakened tendo achillis shortened by operation against body weight exercised during locomotion, it can only have one result, and that is a fresh and speedy yielding of the tendon. If, however, Willet's operation, plus exsection of cartilage, be performed, we shall obtain considerably better results, for on exhibiting the joint from behind we can shorten the tendo achillis and remove sufficient cartilage to limit the action of the ankle to about 20 degrees. The same procedure may with benefit be applied where in addition to an elongated heel tendon the tibiales have been completely paralysed, producing a deformity of calcaneo-valgus with difficulty rectified by hand. I may mention in connection with arthrodesis of the ankle, that one sometimes fails in young children to secure sufficient fixation, and for some time I have removed the upper half of the astragalus and often the inner malleolus of the tibia so that the tibia may fall with greater stability on a good square surface. The result is very satisfactory, and in a completely flail ankle is, I think, more suitable than the recent operation described

by Whitman of New York, of complete removal of astragalus, an operation I have performed on four occasions.

Before leaving the subject of polio-myelitis, I would desire to draw attention to another class of paralytics, the subject of fixed deformities. The hips are flexed, and so are the knees, the ankle is generally extended. If the little patient be made to lie down, marked lordosis of the spine occurs. There has never been any attempt at walking, save perhaps a swinging crutch-supported gait. Power may be found in one sartorius and in one psoas muscle. Can such a case be made to walk, and if so, how? If we determine to try, we will first divide each tendo achillis and place the ankles in rectangular splints. We will next exsect a V-shaped wedge from each flexed knee, the wedge should be sufficiently large to allow of the easy extension of the limbs. For a few weeks the limbs are retained in this position, and a splint, similar to a double Thomas's hip, prepared. The correction of the hip deformities must next be commenced. This must be prosecuted very vigorously. Of all flexion deformities paralytic flexion of the hip is most intractable, and generally the shortened structures are on the outer side of the thighs. A bold incision must be made, and the fascia and every constricting band divided freely until several degrees of flexion are overcome. The patient is then kept upon his double frame for weeks, if necessary, until the lordosis disappears. This is not assisted by re-

course to femoral osteotomy, an operation of very little use in paralytic hip. As soon as the back is straight, place a pair of calliper splints on the little patient, and crutch-aided let him learn to walk. I know of no sensation more delightful to myself, as a surgeon, than that I experience when I see one of these crawling little cripples standing erect before me.

The limited time at our disposal will not allow us to delay longer over spinal paralysis, and I have therefore given you but a brief practical *résumé* of surgical methods, as they appeal to me, endeavouring to enunciate principles in regard to the behaviour of muscles which must always influence, and sometimes govern us, in the line of treatment we adopt.

On Cerebral Paralysis of the Spastic Type.

From spinal to cerebral paralysis is not a long step, and yet what a different field it is to explore. Our spinal case is generally bright and happy, entering into the spirit of our treatment, often with intelligent appreciation. Our cerebral child is uninviting, irritable, and almost always dull, perhaps the most neglected object within the radius of our art. In the short period still at our disposal I desire to point out certain lines of treatment which offer us great encouragement to persevere in our efforts on their behalf. This year I have already written on the spastic type of palsy, and I must beg

your kind indulgence while I repeat the conclusions forced upon me by the consideration of a large number of cases. Although it is quite impossible to discuss fully so complex a subject as cerebral paralysis, I should like to indicate certain types of the affection where surgery may with advantage be employed. For descriptive purposes, cases may be grouped under three headings: (1) Infantile hemiplegia; (2) Cerebral diplegia; and (3) Spastic paraplegia. My own experience would lead me to the conclusion that cerebral diplegia is the commonest group, but of 850 cases which I have collected from various sources, 510 were hemiplegic, 30 monoplegic, 142 paraplegic, 157 diplegic. The diplegic and paraplegic groups are congenital affections, whilst infantile hemiplegia is usually acquired. Infantile hemiplegia generally appears before the fourth year, and is most commonly preceded by convulsions and by acute febrile symptoms, markedly in contrast to the advent of adult hemiplegia. The deformities are of very rapid growth. The arm and leg are powerless and the reflexes exaggerated. The foot is arched and adducted, the knee is bent and the hip is rotated inwards and the femur flexed. The arm clings to the body, the elbow is flexed to a right angle, the wrist is dropped, the hand being pronated and deviating to the ulnar side, while the fingers tightly grasp an adducted thumb. Rigidity comes on nearly always and is increased on passive movement, or when the child attempts to move. The aphasia

is motor and accompanies either right or left hemiplegia. Inequality of growth is the rule, but while the leg hardly ever shortens more than an inch, it is not uncommon to note three inches of difference in the arms. From the point of view of treatment the following facts may prove useful if remembered: (*a*) The arm is more permanently and severely affected than the leg; (*b*) the movements are performed spasmodically, slowly and without precision; (*c*) the power of dorsiflexion of the hand with simultaneous extension of the fingers is lost, and usually the hand has no adduction power. In the lower limb general rigidity is accompanied by extension of the foot, contraction of the knee, flexion and adduction of the hip.

The cerebral diplegic group is far and away the most serious condition to treat. We have here of course to deal with both arms and feet. Unless the hands can be used the surgeon is deprived of his chief allies in the treatment of the limbs. Where the spasm is confined to the limbs alone, we give the name of spastic paraplegia, or Little's disease. The vast majority even of these cases present mental deficiencies of varying extent, and in a considerable minority athetotic movements are also noted.

A typical case of spastic paraplegia, brought to the surgeon at the age of twelve months, is characteristic; usually contractions have occurred at the hip or knee; the child's legs are rigid; the toes are pointed; there is usually no internal

rotation, and adduction is not sufficiently severe to cause a crossing of the limbs. The reflexes are exaggerated, the patellar reflex not usually causing a knee jerk, but a leg jerk. If the little patient be held by its arms there is no endeavour to separate the limbs, and should the toes be brought to the ground and an effort made by the child to walk, both limbs move synchronously and in parallel lines. When passive separation of the limbs is made, although it is easily effected, one can see and feel the antagonistic efforts of the powerful adductors. If at a later stage the patient is able to walk, several changes will be noted. The adduction will be more marked, the scissors walk will have developed, and a characteristic dragging of one knee round the other will be noted, which becomes more pronounced when any attempt at running be made. The body pressure is mainly transmitted to the ball of the toe. These contractures, however, at this stage, are generally spasmodic, and there is no appreciable shortening in muscle length. This shortening occurs at a still later stage, and is known as contracture.

In quite a number of cases the patients are in a hopeless position as far as walking is concerned. Any effort they make to move only serves to throw the muscles into violent contractions, and the legs into extreme adduction. The most severe type of contractions in the legs may be associated with but very slight mental defects and unaccompanied by diplegia.

Before discussing treatment, I will briefly touch upon the pathology of spasmodic paralysis, if only to suggest how futile are operative procedures directed to the primary lesion. The pathological conditions in hemiplegia, paraplegia and diplegia, are the same in kind. The symptoms are due to the retardation of growth, resulting generally from embolism of thrombosis, together with changes in the spinal cord. In later cases one finds wasting and sclerosis of the motor tracts, with often a loss of substance in the form of cavities or cysts known as porencephalus. These cysts occur on the surface of the brain, and sometimes dip fairly deeply into it. They seem to be a late result in a growing brain, and to have produced an extensive scar substitute for cerebral tissue. Should the porencephalus or sclerosis be unilateral, hemiplegia results. If the scar is bilateral, diplegia or spastic paralysis results. The lesions, therefore, are a late product of a hæmorrhage, an embolism or localised encephalitis. In the cord, degenerations of the pyramidal tract or the lateral columns are to be found.

The treatment of spastic paralysis has been too solely in the hands of the physician for much real progress to have been made. Indeed, from medicine in this affection we have but little to expect, apart from very indirect results, and we have only to scan the text-books on neurology, to realise the note of pessimism which is sounded. Even Sir William Gowers in his "Diseases of the Nervous

System," says: "The tendo achillis is sometimes divided for contraction of the calf muscles in infantile spastic paralysis, but the operation is useless, and ought never to be performed." The same opinion has been pronounced by other distinguished men, so one can see how surgery has been silenced in the matter. I would argue that a large proportion of children suffering from severe spastic paralysis, may be transformed into useful members of the community, improved both in body and mind by surgical efforts, enabled to walk with *comparatively* little deformity, generally only requiring the aid to be derived from one or two sticks.

We must place in a group outside remedial art the idiot, the microcephalic and that violent irritable type of diplegic so often seen, subject to fits and active athetotic moments, who has generally lost all control over his secretions. The treatment of any condition short of this may be undertaken with varying success, subject to conditions which obtain in any surgical case requiring prolonged attention. For instance, active treatment may be required for two years. It would therefore be unwise to admit a case into hospital for two months, and then send it to a miserable home where neglect would be sure to follow. Such a case, however, after hospital treatment, happy in the care of anxious intelligent parents, no matter how poor, would prove a credit to all concerned. Another class, which gives the greatest anxiety and

trouble, is that where the affection of the hands is of such a kind as to promise but slight hope of their assistance to the limbs during walking. Before despairing, however, I think it is well to give such hands the opportunity of a careful trial, both as a mental discipline, and because success sometimes exceeds expectation.

I would divide the treatment of all cases of spastic paralysis into operative and post-operative; for although mechanism is involved in nearly every case, there is only an insignificant minority which we are called upon to treat without invoking operative aid.

The treatment of the hand and arm in infantile hemiplegia is distinctly less promising than in the diplegic case, but there are clinical signs to which I would draw your attention, which help us to prognose success or failure. If the paralysis is complete, or in other words, if the little patient is never known to relax his spasm, treatment is futile. If he only moves the fingers of his affected hand in conjunction with the fingers of the opposite side, the results will in all probability be discouraging. In all cases where the parents are able to say, in the spirit of true observers, that the patient is able to do more with the hand now than a little while ago, the success of treatment is assured. Similarly where any degree of voluntary relaxation of spasm exists apart from an associated movement on the opposite side, treatment is emphatically indicated.

Noting that the dominant deformity in both hand

and elbow is pronation and carpal flexion, treatment should consist in fixing the elbow supine and hyper-extending the wrist. The hyper-extension of the wrist should be combined with that of the fingers, and a special arrangement adapted to keep the thumb at right angles to the palm. The spasm in these cases is often so pronounced that the extension of the wrist and fingers must be brought about very gradually. If the elbow is affected by contraction of the biceps and brachialis-anticus, supination may be combined with extension. If this be not the case the flexed position of the elbow will suffice. If, instead of being firmly pronated, the elbow lies semi-proned, it is not necessary to treat it, and all one's energies should be directed to the hands.

If the hemiplegic hand spasm be mild, this treatment may be discarded in about twelve months, provided that during the whole of this period the extension has been kept up without intermission. The test for relaxation must be the power of voluntary movement, however slow it may be. It will be noted that generally at this stage the patient, in endeavouring to extend his wrist, will first of all close his fingers and will only open them on completion of extension. The process is reversed when the wrist is flexed. In order to meet this difficulty the splint employed to extend both wrist and fingers is modified so as to extend the wrist alone, and allow freedom to the fingers.

It is difficult to give a reason as to how improve-

ment comes about, but it may be taken as an axiom that prolonged fixation of spastic muscles in a position opposed to their contraction lessens the severity of their spasm. This is true wherever spasm may be found, and its influence may be tested even in spasmodic torticollis, intractable as we know that affection to be. It would appear as if the group of muscles at last got tired of trying to pull. At this stage or earlier the surgeon may decide whether in a given case success may be predicated, and if he is in doubt, operation should unhesitatingly be performed. Operation will consist of tenotomy or tendon transplantation. An incision is made over the tendon of the flexor carpi ulnaris, just above the annular ligament, another is made over the flexor carpi radialis, and both tendons are divided low down, and are taken (*a*) the flexor ulnaris to be inserted into the extensor ulnaris, and (*b*) the radial flexor into the radial extensor. I performed this operation some time ago upon two spastic children, whom I showed to the Members of the Society for the Study of Disease in Children, and in both instances voluntary movements were steadily performed, and one, a girl of 7, was able to write quite a respectable hand.

My friend, Mr. Tubby, in order to overcome the spasmodic pronation of the forearm, has changed the point of insertion from the front to the back of the radius of the pronator radii teres, and has succeeded in transforming the muscle into a supinator.

Tenotomy alone has proved somewhat disap-

pointing, though one has had an occasional successful case. The operation should be confined to the division of the flexor carpi radialis and ulnaris. It is in my opinion better to elongate the other flexors of the hand by a long median incision, such as one would employ in lengthening the tendo achillis. Tendon transplantation, however, is a better operation, less complicated and more reliable. The surgeon's art does not end with the operation, and hyper-extension of the wrist, leaving the fingers free, should be practised for a further few weeks. In order to prevent adhesions after the operation, the wrist should be freely, but very gently withal, moved in about a fortnight's time. Whether an operation has been performed or not, the final stages of treatment are identical. They should consist in getting both guardian and patient to strain every nerve to urge and practise movements from simple to complex.

The nature of the movements to be practised must be left to the ingenuity of the surgeon. The principle which should govern him may, however, be here indicated: (*a*) the movements should be practised slowly and without excitement; (*b*) they should be made interesting to the child; (*c*) those opposed to the direction of deformity should predominate; (*d*) those presenting the greatest difficulty should be chiefly practised.

Just a word before we deal with paraplegia regarding tenotomy of the spastic muscle. Empiricism has taught us that for some reason or another

tenotomy lessens both in frequency and intensity the spasmodic element in paraplegia. I do not merely mean to say that division of the tendo achillis controls spasm in the calf muscles, although of course it does, but rather that spasm in which those muscles are not directly concerned is also influenced. This is beyond all question and must have been noted by everybody who has had the opportunity of observing, and the fact has now reached the robust stage when physiological explanations are vouchsafed.

Whitman urges that by elongation of the tendon the response to the exaggerated motor impulses is lessened, and an opportunity for more effective control is afforded. Discussing the question with Mr. Tubby, he propounded the theory that once the immediate pathological effect of the central nervous lesion had subsided, the spinal cord remains in a state of undue reflex excitability. A tightly contracted muscle and tendon tend to augment this condition and so induce in themselves further contractions. In other words, there is a vicious circle of reflex action which can be interrupted by section of the tendon, and diminution of the tension of the affected muscle and tendon.

Lorenz attributes the good effect to the shortening of the bellies of the tenotomised muscles so that their range of action is diminished. Both these theories refer, of course, to spasm in which the divided muscle is concerned, and do not explain the diminution in spasm experienced elsewhere.

We must further remember that the opponents of contracted muscles are always elongated and weak and that the rest afforded them by tenotomies, by relieving them of strain, helps to restore muscular equilibrium.

The practical deduction from these observations is, that no opportunity should be lost of performing a tenotomy. Even in mild cases, where a spastic tendon is to be felt, we need have no hesitation in dividing it.

If the surgeon has decided that a case of spastic paralysis is suitable for treatment, a splint should be prepared so designed as to keep the limbs in pronounced abduction. The area over the hamstrings, the adductors at the groin, and the tendo achillis should be suitably prepared for operation. The adductors should be first attacked. An incision an inch or two long should be made to the inside of the adductor longus. This muscle should be seized by a forceps and about $\frac{3}{4}$ inch of it removed. The limb is then abducted and portions of the adductor brevis and gracilis are exsected in similar fashion. The horizontal portion of the adductor magnus, and if necessary, the pectineus, is divided, and also any tissue, muscular or fibrous, obstructive to an absolutely free abduction of the femur. Experience has shown me that although the chief offenders are the adductors longus and brevis, nevertheless the deeper muscles often require division. To anyone who has practised the operation, the futility of attempts to divide the

muscles effectively subcutaneously, will be apparent. Division is followed with but little hæmorrhage and the wounds are closed without drainage. Having exsected the pieces of the adductors each tendo achillis is divided, or, better still, elongated, for we often note that after division of the tendon outright, there is a tendency to walk too much on the heel. Rectangular splints are then applied to the foot. The limbs are then well abducted and the surgeon notes whether there is any obstacle to easy extension of the knees. If there should be (it is not often the case) an open incision must be made on each side of the popliteal space and the tense hamstrings are in turn divided. If these incisions are long enough the fascial contraction can be attacked on either side, for it is here that opposition is found. I would discourage the use of a transverse incision, as when adopted it often seriously hampers the surgeon's efforts to fully extend the knee by reason of the strain cast upon the sutures. Simple division, however, with fasciotomy, usually suffices to allow of easy extension, and excision of tendons could do no more. In 1885, when I was at the Stanley Hospital, there used to be an adult diplegic always at the gates in a perambulator, and on two or three occasions I took him in to try and straighten his contracted limbs. On one occasion I removed about an inch from each of the hamstrings, but he was mentally so deranged that we did not do each other any credit. I mention the fact, however, because

Lorenz of Vienna has quite recently written on the advantage of exsecting portions of the hamstrings.

We have now presumably got our patient stretched comfortably upon an abduction frame, and we must keep him there for three months. The wounds heal very rapidly and suppuration has occurred in the adductor cavity on three occasions only, despite the insanitary position of the wounds and the number of operations performed; for instance, in 1890 I operated on 27 patients, and this may be taken as a fair index of my yearly return.

At the end of three months the splint is taken off during the day and movements are sedulously practised. For some weeks stiffness exists and often the movements are at first painful, but after a time (always shortened by vigorous exercise) the pain disappears and the effort must be made to walk.

The splints are of a simple kind, designed to keep the knee from bending. The boots should be made of felt with substantial soles. The nurse should be instructed to keep both boots and splints upon the patient day and night, and, for the first two weeks, frequently during the day, abduction, adduction, flexion and extension of the hips should be practised. This should be done with and without resistance. At night time the feet should be attached to the side of the bed, in order to obtain abduction. After the first few days of this later stage of treatment the splints should be removed twice a day and the muscles well massaged, and

both active and passive movements of ankles, toes, knees and hips, encouraged. Any movement executed in a jerky style should be practised until perfected.

The little patient may now try to walk. It will be noted that one of the difficulties of an untreated spastic when he tries to walk, is the narrowing of the pedestal upon which the trunk rests by reason of adducted limbs. Operation has now overcome this, and with abducted limbs the body is poised upon a pedestal that is widened. During early training the nurse must see that while walking the limbs are not approximate, and that from the first swinging, aided by crutches, must be prevented. Crutches should not be allowed until the patient has been taught to stand unsupported. I need not enter into any more detail regarding this most important stage of treatment, but would add that it affords an inexhaustible field for ingenuity, and that upon the intelligence and industry of the nurse very much depends.

I cannot now deal with individual cases, but I may say that I have operated upon cases from 12 months to 20 years of age. A large number of these were so bad that they had never attempted to place one foot before the other. Some were structurally flexed (contracted) at ankle, knee and hip. A most helpless youth of 20, one limb across the other, was able in six months to stand erect and walk with sticks, and twelve months later was able to move his limbs north, south, east

and west with hardly an appreciable jerk. Success in an ancient case where so much has to be unlearnt, and where the mechanical stage offers so much difficulty, proves the soundness of the principles I have endeavoured to expound. It is logical to infer that if old neglected cases are amenable to surgical education, our prognosis should be very hopeful in the young.

With regard to the degree of benefit to be derived from treatment, the parents should be given to understand that, under favourable conditions of nursing and tuition, the child, aided by the hand or sticks, will be able to walk distances in from twelve months to two years, and that with perfectly straight limbs and heels on *terra firma*. A large proportion of cases will, later on, manage aided by one stick. Even in the least successful cases parents, mostly having despaired, are full of gratitude. The mental condition of the children obviously improves when their physical defects are remedied, and they are enabled to mix with their little friends. Complete recovery in spastic paraplegia is, of course, impossible.

It will be gathered from my remarks that the treatment of spastic paralysis should resolve itself into a system. That system involves operative, mechanical and educational stages. The treatment cannot be separated into parts. If the surgeon is not satisfied that the case is to be under his control for twelve months he will consult his reputation best by leaving it alone. Opera-

tions, not followed up by careful and prolonged after-care, give rise to disappointment and discredit. Merely dividing tendons and trusting to massage and electricity is futile and dispiriting.

In conclusion, gentlemen, I would say that infantile paralysis offers an immense field for surgical enterprise, and if I have succeeded in even suggesting to you some of the possibilities, your time will not have been altogether wasted.

I beg to thank you for your patient hearing.

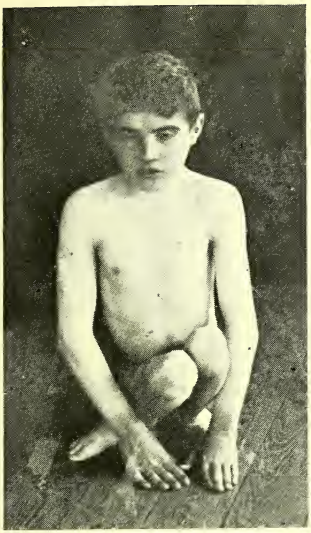

Fig. 1.—T. S. Infantile paralysis. Patient unable to stand since birth. Flail paralytic deformities.

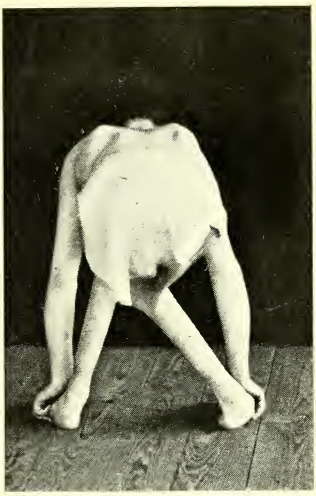

Fig. 2.—T. S. Method of progression. Patient lifts his feet with his hands.

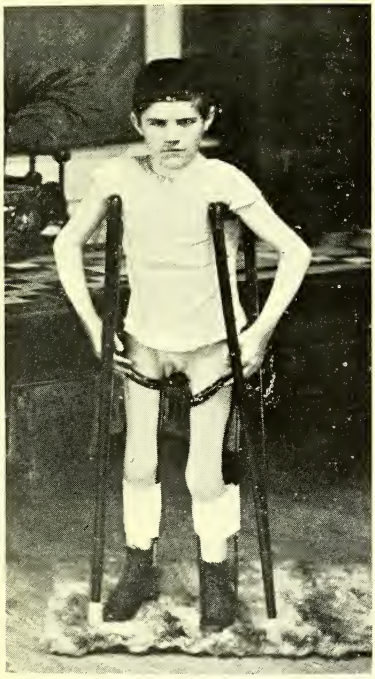

Fig. 3.—T. S. After arthrodesis of one knee and both ankles, and osteotomy of the knees.

Fig. 4.—T. S. Some months later. He now walks with sticks.

Bale and Danielsson, Ltd.

Fig. 5.—Fixed paralytic deformities. Marked lordosis, genu valgum, flexion of hips and knees, extension of ankles.

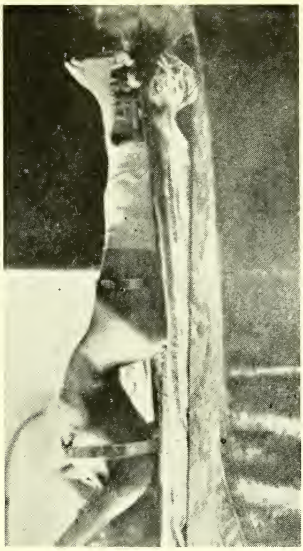

Fig. 6.—Same case undergoing treatment for lordosis.

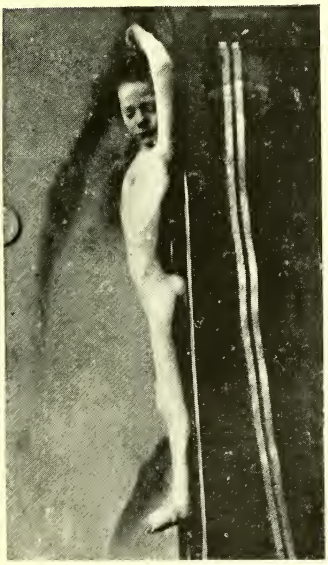

Fig. 7.—Showing the lordosis disappearing.

Fig. 8.—Now in a position to walk.

Bale and Danielsson, Ltd.